

Introduction to Science and the Chemistry of Life

I Nature of Science

1. Forms

- a) Pure Science - study for the pure gain of knowledge
- b) Applied Science - directed study to solve a known problem.

2. Procedures of Science - the Scientific Method

- a) Observation - measurable, unbiased observations
- b) Hypothesis - cause and effect or Null
- c) Experimentation - use of control, sufficient numbers, unbiased analysis
- d) Theory - a working explanation of cause and effect with predictive value.
- e) Law - a proven theory in all measurable situations.

3. Limitations of Science

- a) Scientific Domain - must be able to apply the Scientific Method to the area
- b) Aims of Science - "to make and use theories"

4. Divisions of Biological Sciences

- a) botany
- b) zoology
- c) microbiology
- d) anatomy
- e) physiology
- f) embryology
- g) genetics
- h) taxonomy
- I) cytology
- j) histology
- k) ecology

II Nature of Life

1. Levels of Organization

atoms
molecules
compounds
organelles
cells
tissues
organs
organ systems
organism
population
community
ecosystem
biosphere

III Chemistry of Life

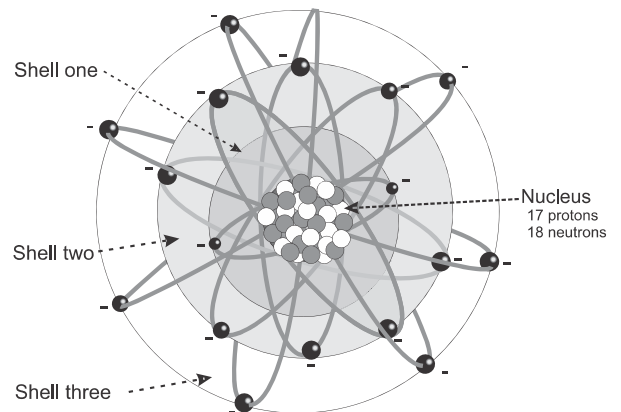
1. Elements

92 naturally occurring kinds
~ 20 kinds in cells

2. Atom

nucleus - center mass
shells - arrangement of electrons

atomic number - number of protons
atomic weight - protons plus neutrons
proton number - determines the element
electron number - equal to the proton #
valence - # of electrons in the outermost shell
isotopes- same # of protons, different # of neutrons.



Hypothetical Atom

Octet rule - all shells have a tendency to have 8 electrons in them except for the first shell which has 2.

Ia IIa IIIb IVb Vb VIb VIIb VIII Ib IIb IIIa IVa Va VIa VIIa 0

1 H Hydrogen																	2 He Helium						
3 Li Lithium	4 Be Beryllium																	5 B Boron	6 C Carbon	7 N Nitrogen	8 O Oxygen	9 F Fluorine	10 Ne Neon
11 Na Sodium	12 Mg Magnesium																	13 Al Aluminum	14 Si Silicon	15 P Phosphorus	16 S Sulfur	17 Cl Chlorine	18 Ar Argon
19 K Potassium	20 Ca Calcium	21 Sc Scandium	22 Ti Titanium	23 V Vanadium	24 Cr Chromium	25 Mn Manganese	26 Fe Iron	27 Co Cobalt	28 Ni Nickel	29 Cu Copper	30 Zn Zinc	31 Ga Gallium	32 Ge Germanium	33 As Arsenic	34 Se Selenium	35 Br Bromine	36 Kr Krypton						
37 Rb Rubidium	38 Sr Strontium	39 Y Yttrium	40 Zr Zirconium	41 Nb Niobium	42 Mo Molybdenum	43 Tc Technetium	44 Ru Ruthenium	45 Rh Rhodium	46 Pd Palladium	47 Ag Silver	48 Cd Cadmium	49 In Indium	50 Sn Tin	51 Sb Antimony	52 Te Tellurium	53 I Iodine	54 Xe Xenon						
55 Cs Caesium	56 Ba Barium	57 La Lanthanum	72 Hf Hafnium	73 Ta Tantalum	74 W Tungsten	75 Re Rhenium	76 Os Osmium	77 Ir Iridium	78 Pt Platinum	79 Au Gold	80 Hg Mercury	81 Tl Thallium	82 Pb Lead	83 Bi Bismuth	84 Po Polonium	85 At Astatine	86 Rn Radon						
87 Fr Francium	88 Ra Radium	89 Ac Actinium																					

Atomic Number

Symbol

Atomic Weight

Metals

Nonmetals

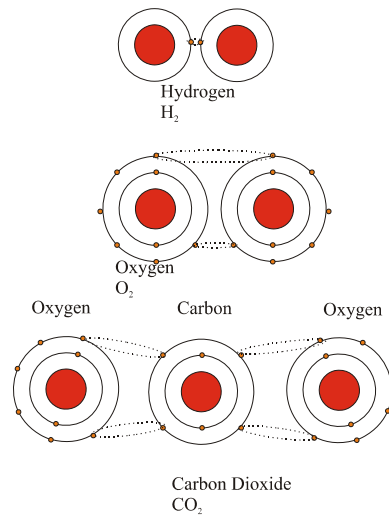
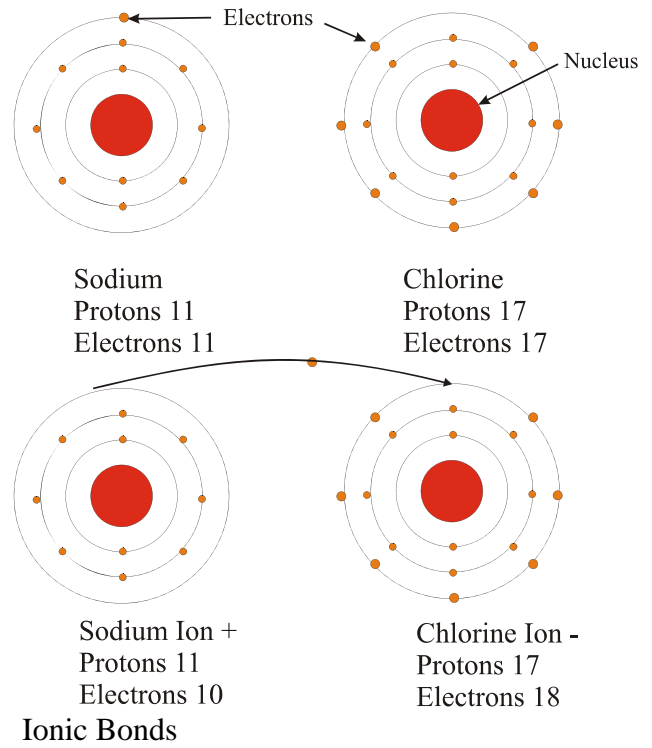
58 Ce 140	59 Pr 141	60 Nd 144	61 Pm 147	62 Sm 150	63 Eu 152	64 Gd 157	65 Tb 159	66 Dy 163	67 Ho 165	68 Er 167	69 Tm 169	70 Yb 173	71 Lu 175
90 Th 232	91 Pa 231	92 U 238	93 Np 237	94 Pu 242	95 Am 243	96 Cm 247	97 Bk 247	98 Cf 249	99 Es 254	100 Fm 253	101 Md 256	102 No 254	103 Lr 257

3. Bonding

a) Ionic Bonding

b) Covalent Bonding

c) Hydrogen Bonding

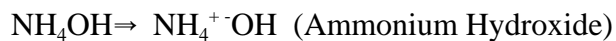
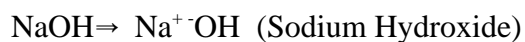


Covalent Bond

4. pH: Acid - Base Relationships

<u>pH Value</u>	<u>Log</u>	<u>Number of Hydrogen Ions</u>	
pH 1	10^{-1}	.1	H^+
pH 2	10^{-2}	.01	H^+
pH 3	10^{-3}	.001	H^+
pH 4	10^{-4}	.0001	H^+
pH 5	10^{-5}	.00001	H^+
pH 6	10^{-6}	.000001	H^+
pH 7	10^{-7}	.0000001	H^+
pH 8	10^{-8}	.00000001	H^+
pH 9	10^{-9}	.000000001	H^+
pH 10	10^{-10}	.0000000001	H^+
pH 11	10^{-11}	.00000000001	H^+
pH 12	10^{-12}	.000000000001	H^+
pH 13	10^{-13}	.0000000000001	H^+
pH 14	10^{-14}	.00000000000001	H^+

Strong acids and bases vs. weak acids and bases



Buffers

Weak Acid or Base

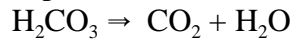


5. Types of Chemical Changes in Cells

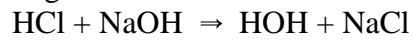
a) Synthesis



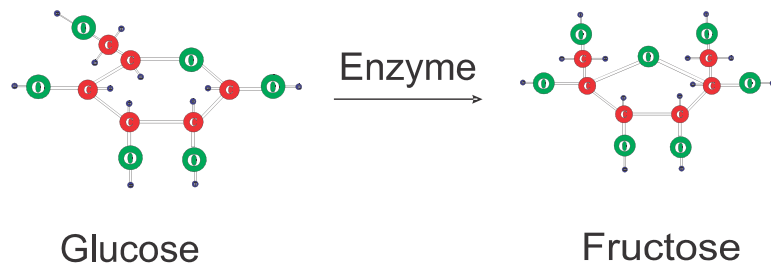
b) Decomposition



c) Exchange



d) Rearrangement



6. Catalyst

a) Definition : Speeds up reaction, determines direction, takes place of external heat, and not used up in the reaction.

b) Biological Catalysis - Enzymes (proteins)

c) Lock and Key model theory of enzyme activity

d) Enzyme characteristics

- 1) Temperature
- 2) pH
- 3) concentration
- 4) heavy metals
- 5) pressure

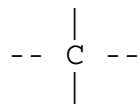
7. Important Biological Compounds

a) Water H₂O

- 1) Universal Solvent
- 2) Cohesive and Adhesive Properties
- 3) High Specific Heat
- 4) High Boiling Point
- 5) Coolant
- 6) Less dense as solid than as a liquid.

b) Carbon

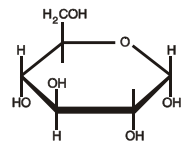
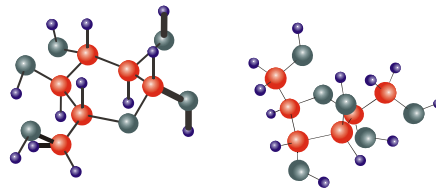
- 1) Covalence of four



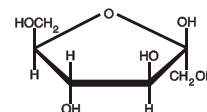
- 2) Can bond with C, H, O, N
- 3) Form chains and rings

c) Carbohydrates

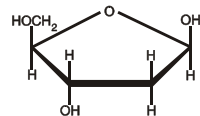
- 1) Monosaccharide



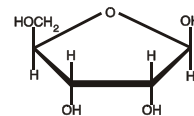
Glucose



Fructose



Deoxyribose

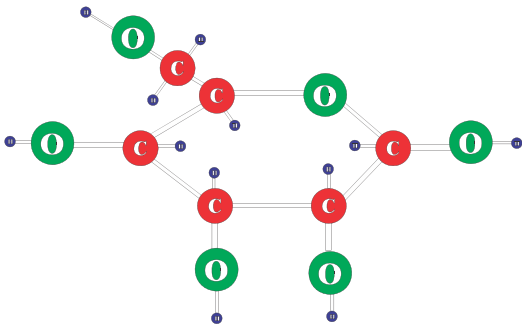


Ribose

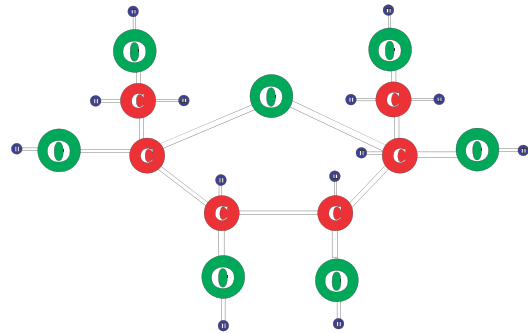
Simple Carbohydrates

2) Disaccharide

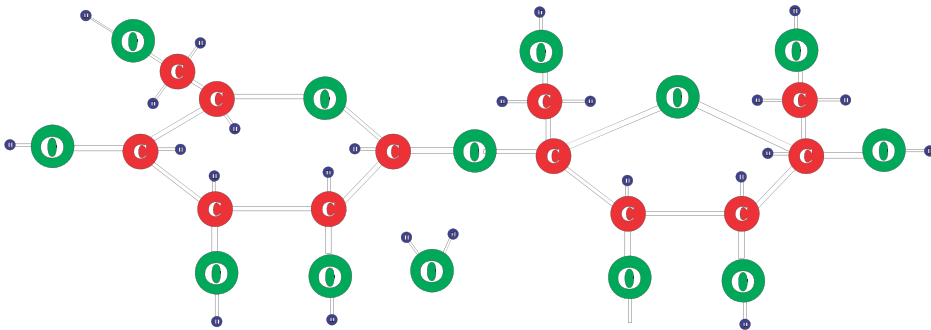
3) Polysaccharide



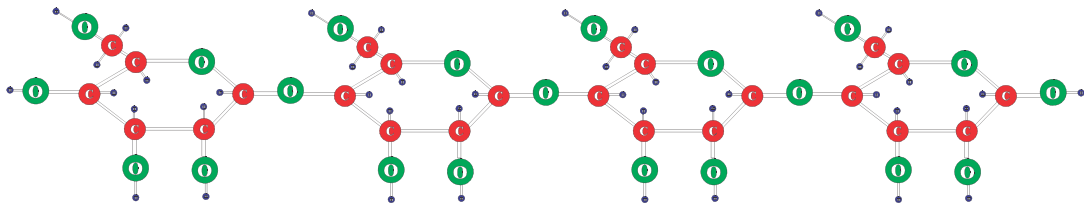
Glucose



Fructose



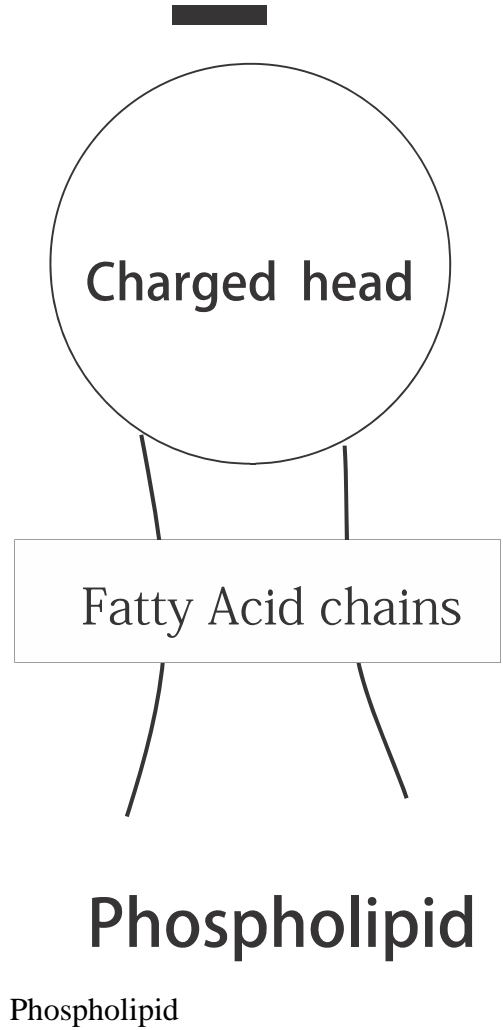
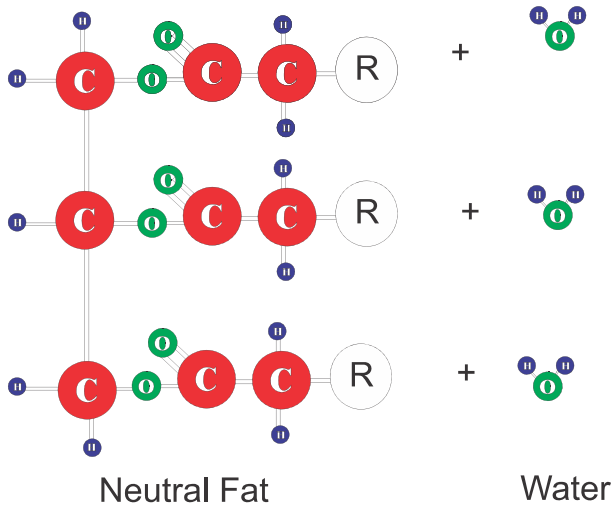
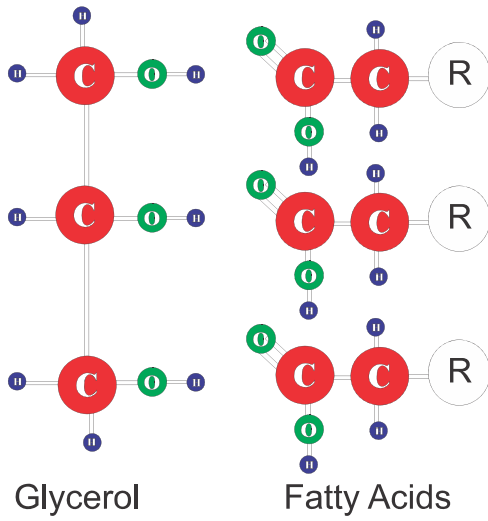
Sucrose



Polysaccharide

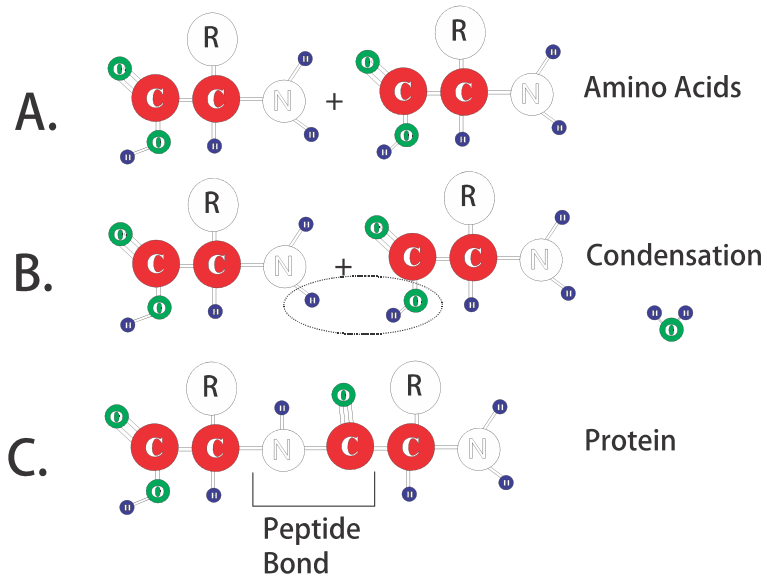
d) **Lipids**

- 1) glycerine
- 2) Fatty Acids
- 3) Saturated vs. unsaturated
- 4) Phospholipids: Substitution of a Charged phosphate group for third fatty acid chain



e) Proteins

- 1) Amine groups
- 2) Carboxyl groups
- 3) Amino acids
- 4) Peptide bonds
- 5) 20 amino acids make up all cellular protein and enzymes
- 6) Primary Structure, Secondary Structure, Tertiary



- 7) Coagulation affected by:
- heat
 - pressure
 - electricity
 - heavy metals

f) Nucleic Acids

1) Nucleic acids = nucleotides

2) nucleotides = nitrogen base + sugar + phosphate complex

3) Nitrogen bases

adenine
guanine
cytosine
thymine
uracil

4) Sugars C₅

Deoxyribose
Ribose

5) Two kinds of Nucleotides

ribose nucleotides
deoxyribose nucleotides

6) Ribose nucleotides

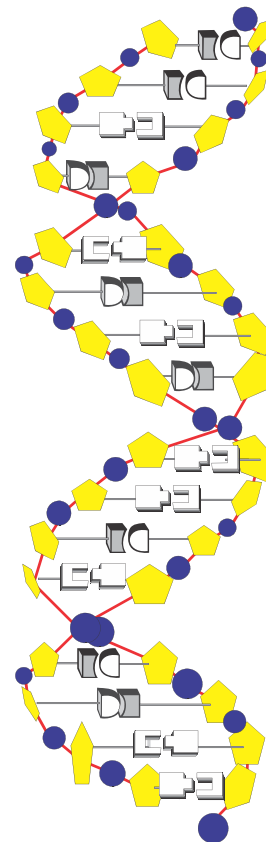
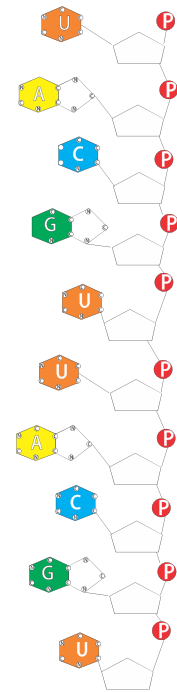
adenine ribose phosphate
guanine ribose phosphate
cytosine ribose phosphate

uracil ribose phosphate

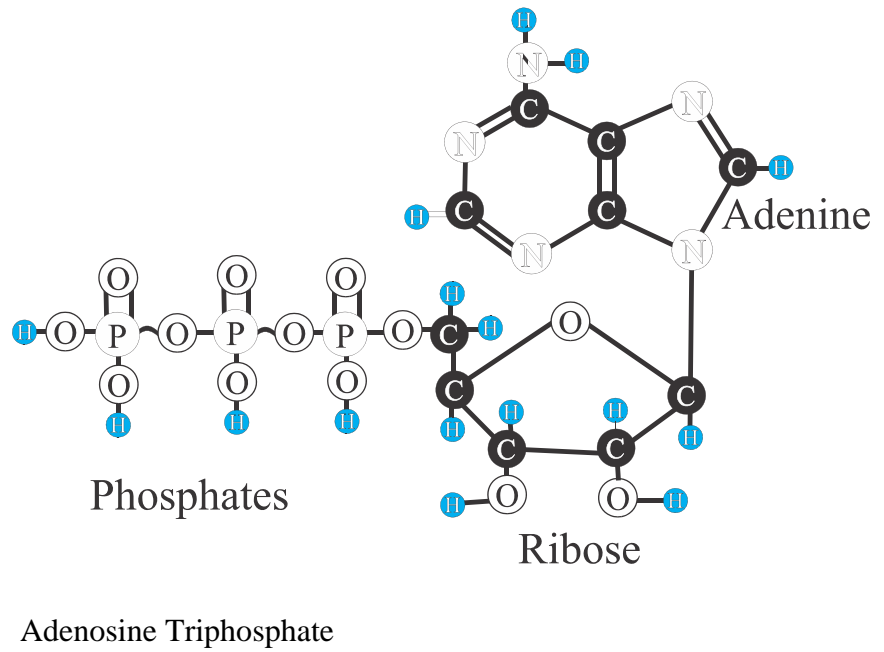
7) Deoxyribose nucleotides

adenine deoxyribose phosphate
guanine deoxyribose phosphate
cytosine deoxyribose phosphate
thymine deoxyribose phosphate

8) Structure



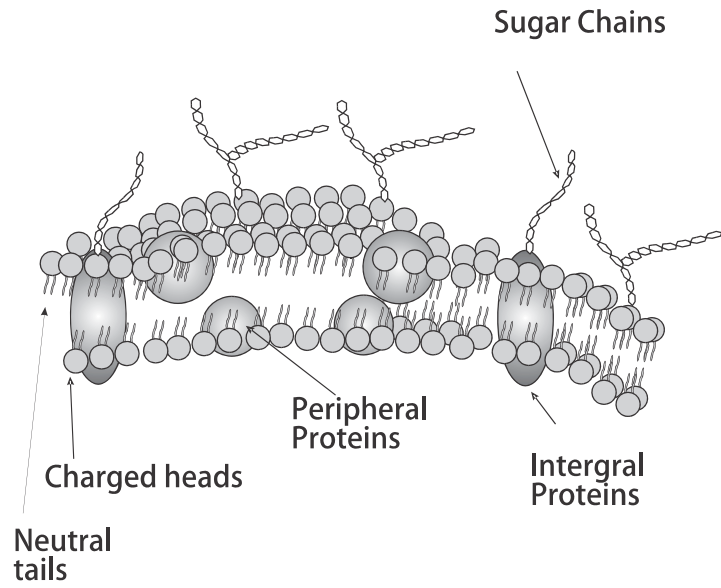
ATP



III The Cell

2. Structure of the Cell

a) Cell Membrane



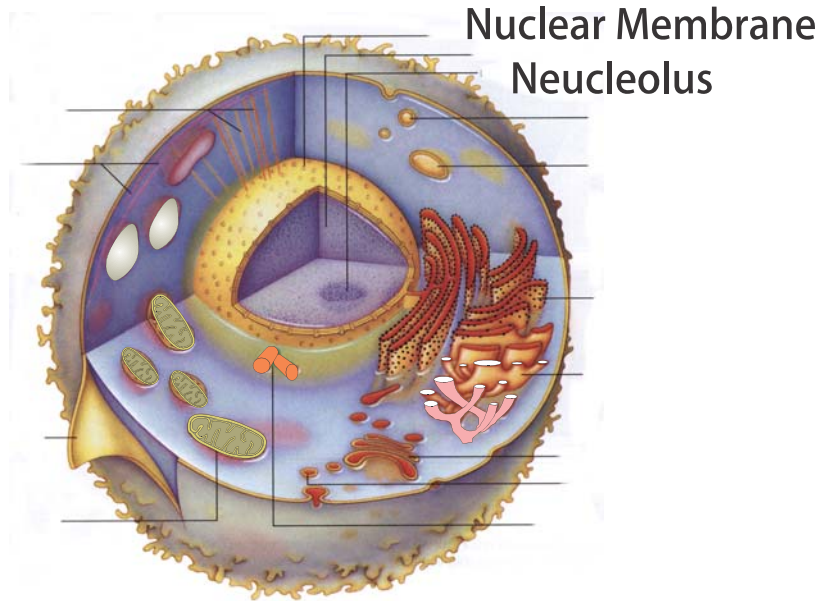
1) Peripheral proteins

2) Integral proteins

3) Glycocalyx - cell coat plays a part in blood type, immune response, tissue rejection and cell recognition.

b) Nucleus and nucleolus

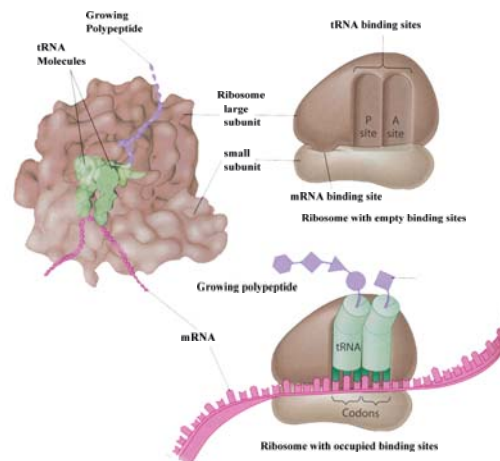
- 1) chromatin
- 2) nuclear envelope
- 3) nuclear pores
- 4) nucleolus "nuclear organizer" makes nucleic acids DNA, RNA, ribosomes



Nucleus

c) Ribosomes

- 1) Two subunits
- 2) moves to E. R.
- 3) functions in protein synthesis



d) Endoplasmic Reticulum

- 1) Passage ways throughout the cell
- 2) Rough E.R. protein synthesis
- 3) Smooth E. R.- fat and steroid synthesis

e) **Golgi apparatus**

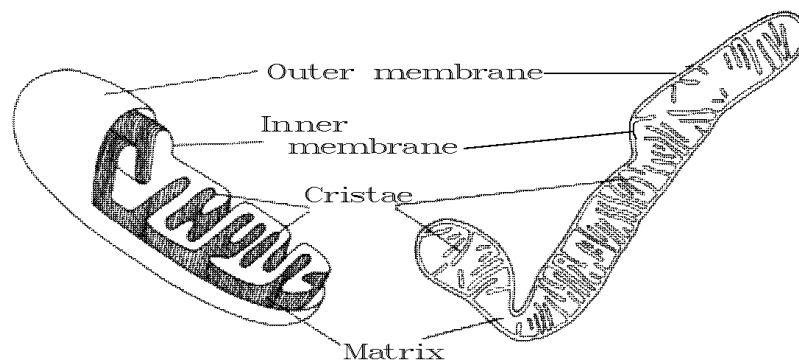
- 1) Packaging and secretion of all smooth E.R. products
- 2) Production of secretory vesicles such as lysosomes

f) **Lysosomes**

- 1) contains strong digestive enzymes
- 2) fuses with other vesicles to function
phagocytic vesicles
autophagic vesicles

g) **Mitochondria**

- 1) "power house" of the cell
- 2) Rod shaped, double membrane
- 3) Inner membrane forming cristae
- 4) F₁ Factors
- 5) The matrix of organelle contains ribosomes all of which resembles DNA bacteria more than the parent cell.



h) Plastids

1) Leucoplast

Manufacture of starches and storage of fats, starches, oils and proteins

2) Chromoplasts

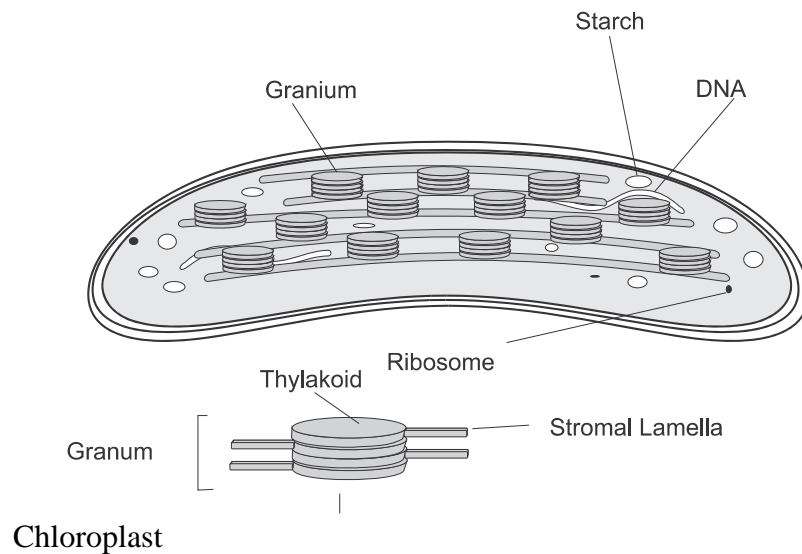
Many different kinds containing specialized pigments, yellows, red, orange. Imparts colors to fruits, flowers, seeds and fall leaves.

3) Chloroplast

Thylakoid : Light reaction

Grana : Photosynthesis

Stroma : Dark reaction



4) Cell Vacuoles

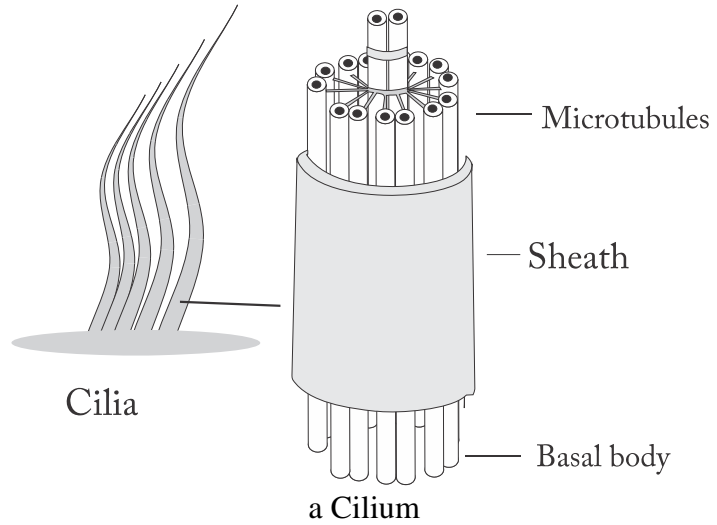
Large concentrations of sugars, organic acids, proteins, plant pigments, salts. May help in the cell elongation process

5) Flagella and Cilia

(a) Structure - nine double tubules, with two central tubules

(b) Cilia and flagella have same basic structure.

(c) basal bodies give rise to both and have a similar structure (minus the central tubules).



6) Centrioles

(a) same structure as basal bodies.

(b) play a visible role in cell division, but not necessary to complete it.

(c) thought to be an archaic structure

7) Cell Walls

(a) Middle lamella - pectin

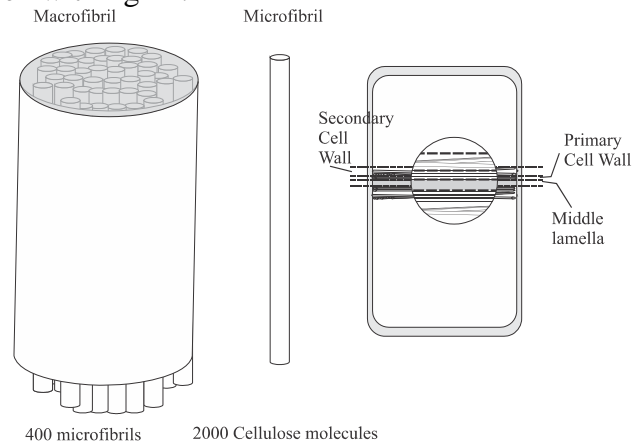
(b) Primary cell wall

microfibril - 2000 cellulose molecules

macrofibrils - 400 microfibril

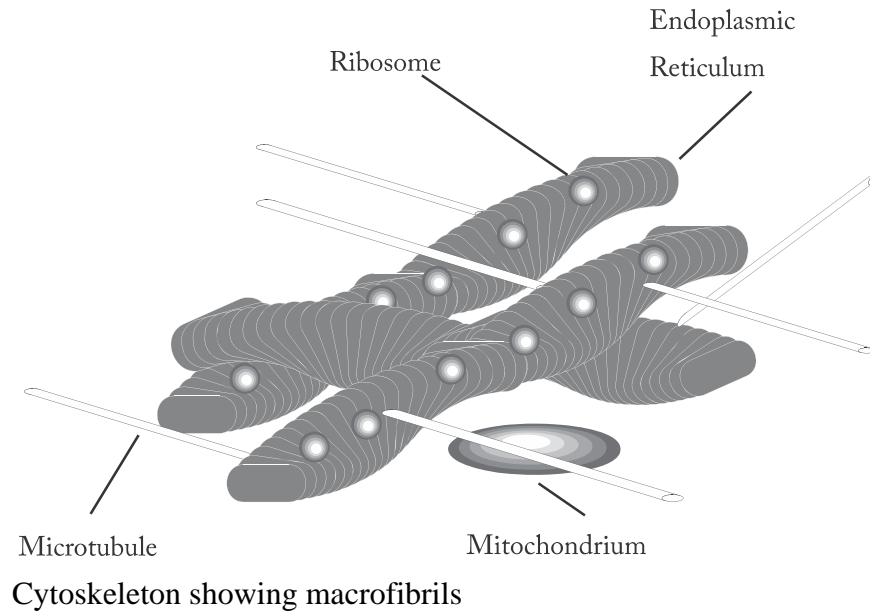
(c) Secondary cell wall

Laid down after mature, strengthen with lignin.



8) Cytoskeleton

Made up of micro tubules holding the framework of the cell together.



IV Cell Fluid Transport

1) **Brownian Movement**

molecular motion

2) **Diffusion**

Movement of molecules from areas high concentration to areas of low concentration.

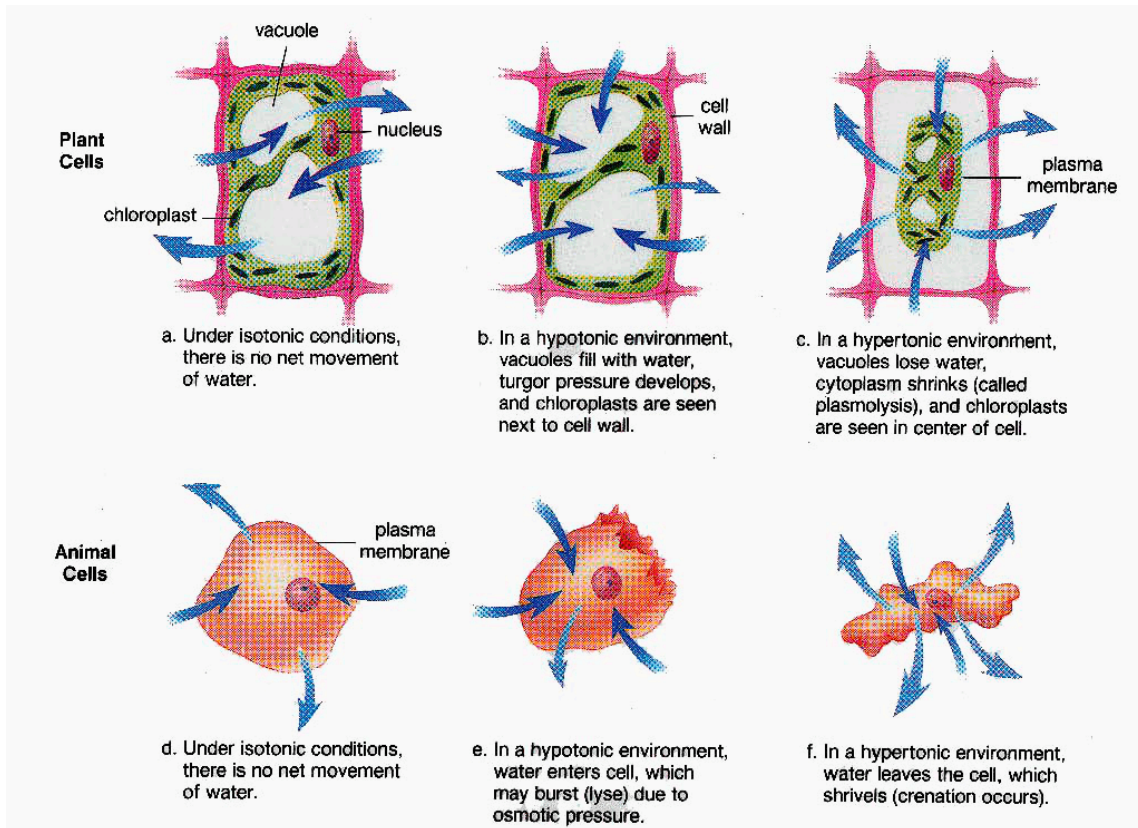
3) **Osmosis**

Tonicity:

Isotonic- equal dilutions of solute

Hypotonic - under soluted, more solvent

Hypertonic- overly soluted, less solvent



4) Active Transport

Can move against a concentration gradient. Large molecules unable to move through the membrane, are moved through the integral proteins using ATP as an energy source.

Review Questions

1. Give an example of a synthesis.
2. Give an example of a decomposition.
3. Give an example of an exchange.
4. Give an example of a rearrangement.
5. What is the realm of science and where does it not belong?
6. What are the steps of the scientific method?
7. What is the smallest particle in nature?
8. Define an ionic compound.
9. Define a hydrogen bond.
10. What is diffusion?
11. What is active transport?
12. What is the major objective of science?
13. What is a buffer?
14. In the structure of a stick model of a molecule, what does the "line" represent?
15. What do organic compounds have in common?
16. What is a control?
17. Be able to recognize the graphical representations of the major organic compounds.
18. What is a nucleotide composed of?
19. In the formula where a "P" has a circle around it, what does it indicate?
20. Name the four nitrogen bases associated with RNA.
21. Name the four nitrogen bases associated with DNA.
22. What are the base pairings between adenine, guanine, thymine and cytosine?

23. Where in the cell would find DNA and RNA?
24. Name the sugars associated with RNA and DNA.
25. What kind of chemical bond maintains rung structures in DNA?
26. What kind of chemical bond maintains primary structure of proteins?
27. What kind of chemical bond maintain the secondary and tertiary structures of proteins?
28. Name an example of a monosaccharide, a disaccharide and a polysaccharide.
29. Recognize ATP and the role it plays in the cell.
30. When monomers combine, what kind of reaction is involved?
31. When polymers are broken down, what kind of reaction is involved?
32. The "R" group indicated in amino acids and fatty acids indicates what?
33. How many naturally occurring amino acids are there?
34. Name the two components of a lipid?
35. A unit of pH change actually indicates a change of what in Hydrogen ion concentration?
36. How does a Phospholipid differ from a normal lipid?
37. What makes one fat saturated and another unsaturated?
38. What determines the state of a lipid (an oil, wax, lard or fat)?
39. What is the role a catalyst in a chemical reaction?
40. What are the formulae for a carboxyl, amine group and hydroxyl group?
41. What in an atom determines the kind of element?
42. How would you determine the electron number if your were given mass and neutron number?
43. What determines the chemical reactivity of an element?

44. How would you determine the electron distribution in a atom?
45. How is the atomic number of an element determined?
46. What is the special bond called which connects amino acids together?
47. Recognize the chemical symbols for carbon, iron, calcium, hydrogen, oxygen, nitrogen, potassium and sodium.
48. The transport of water across a cell membrane is called what?
49. What is a microfibril?
50. What is the middle lamella?
51. What is the function of the endoplasmic reticulum?
52. What organic compounds are represented by enzymes?
53. What are the granulations in a granulated endoplasmic reticulum?
54. Why is a carbon important in the formation of organic compounds?
55. What is the function of the mitochondria?
56. What is the function of the microtubules?
57. What is the cell theory?
58. What is the function of the flagellum?
59. What is the function of plastids?
60. What is(are) the function(s) of the Golgi bodies?
61. What is the function of the smooth endoplasmic reticulum?
62. What is the function of the lysosome?
63. What are the functions of the nucleolus?
64. What is the function of the vacuole?

65. What functions are accomplished by the cell membrane?
66. What is the role of the centrioles?
67. What is a Leucoplast?
68. What is a ribosome and where is it manufactured?
69. What is the difference between isotonic, hypotonic and hypertonic?
70. What is an isotope?
71. What organelles pass through the nuclear pores?
72. What is the difference between active transport and passive diffusion?
73. What structures in the cell membrane allow for cell recognition?
74. Through what substructures do the water molecules pass?
75. What part of the cell membrane contains an electrical charge?
76. What organelles are only found in plants?
77. What organelles are found just in animals?
78. In photosynthesis, where does the light reaction take place?
79. In photosynthesis, where does the dark reaction take place?
80. Be able to recognize all chemical diagrams and be able to label them.
81. What makes up an atom?
82. How do enzymes work?
83. What is a peptide?